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EPA RESPONSE  
TO  
COMMENTS FROM MANVILLE CORPORATION  
ON EPA'S ADDENDUM TO FINAL FEASIBILITY STUDY  
AND PROPOSED COVER THICKNESS

by  
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INTRODUCTION

The Comments referred to in this document are those signed by Marvin Clumpus, P. E., Project Coordinator for Manville Service Corporation, and by John A. Zackrison, Esq., of Kirkland and Ellis, Washington, D.C., dated February 24, 1987, and titled as shown above. Statements made in those Comments which question the potential hazard of off-site migration of asbestos or other substances at the Waukegan, Illinois disposal site are addressed by EPA in a separate report.

The document herein has been prepared by Richard W. McGaw, P. E., Civil Engineering Consultant to EPA, who is responsible for the recommendation of soil cover thickness at the Johns-Manville waste disposal site at Waukegan, Illinois.

It specifically addresses those portions of the Comments that refer to technical questions of frost penetration and the upfreezing of asbestos material through the soil cover. The format is such that statements appearing in the Comments which are critical of EPA's technical approach are given verbatim in the order in which they occur; the EPA response follows the statements.

#### GENERAL CRITICISMS

Relative to the problem of assuring that future asbestos contamination does not occur owing to the upward movement of asbestos under the action of freezing and thawing, beginning on p. 4 of the Comments several claims are made relative to EPA's technical approach. These are essentially assertions which remain unsubstantiated at this point in the Comments. Nevertheless, EPA has considered each claim carefully.

The claims are listed below exactly as they are stated; the EPA response follows.

- a) "EPA's Addendum and supporting documentation is inaccurate, inconsistent, misleading and unreliable";
- b) "The Addendum's upfreezing analysis is unreliable and unscientific";
- c) "It uses or relies upon shifting and inconsistent thermal parameters";
- d) "It makes shifting and undocumented assumptions of questionable reliability";
- e) "It makes many undocumented factual claims" (i.e., claims

of fact);

- f) "Its analysis of freezing depth omits the impact of frost heave";
- g) "It fails explicitly to account for known variability in the parameters, and uncertainty concerning field conditions";
- h) "Its use of the Modified Berggren equation, the fundamental analytical tool in the analysis, is irregular and marred by improper use of parameters (thermal conductivity values, latent heat values, and failure to correlate assumptions regarding parameters)";
- i) "In short, EPA's Addendum on its face lacks scientific or technical credibility, validity, and reliability as a basis for a 24-inch cover recommendation".

#### EPA RESPONSE TO GENERAL CRITICISMS

The supporting documentation referred to in these claims is the Appendix to the EPA Addendum, entitled "Principles and Practice of Design of Soil Cover for Waste Asbestos in Northern Areas, with Calculation of Minimum Cover in Open Areas of the Johns-Manville Asbestos Disposal Site in Waukegan, Illinois", dated January 1987. This Appendix was prepared by the writer and describes a state-of-the-art procedure for estimating frost penetration in various types of soil and freezing climates; it is based on 30 years of personal research as a member of the U.S. Army Cold Regions Research and Engineering Laboratory in Hanover, New Hampshire (a Corps of Engineers laboratory). The writer's specialties

in this work from 1956 to 1986 were soil mechanics, thermal properties of soils, and frost heaving; he performed both theoretical and experimental studies in these subjects and authored some 30 technical reports and papers. A bibliography is available.

The EPA procedure used by the writer to estimate frost penetration, and to control the upfreezing of asbestos particles by limiting the number of freezing penetrations into the waste deposit, is standard engineering practice in cold regions design. Rather than being unreliable and unscientific, as is claimed above, it is in fact an application of the "limited subgrade frost protection" design procedure developed and used by the Corps of Engineers since about 1946. It results in an expedient and more economical cover thickness than would the more conservative "full subgrade protection" procedure which does not allow frost penetration to extend below the covering layers of soil.

Because governing regulations require a permanent cover over the waste asbestos, it is within EPA's authority to require full subgrade protection corresponding to a cover thickness sufficient to maintain the waste deposit below the maximum depth of frost penetration indefinitely. Clearly, this type of design would provide the greatest degree of protection from future airborne asbestos.

On a small site, full subgrade protection such as this may be justified. On sites with large areas to be covered,

however, such as the Waukegan site, cost is a factor which is to be weighed against the degree of protection provided. The basic difference between the cover thickness proposed by EPA and that proposed by Johns-Manville (J-M) is the degree of risk considered acceptable in dealing with asbestos, a substance known to be hazardous to health: EPA chooses to rely on proven practice that limits the number of frost penetrations into the asbestos (each of which lessens the effective degree of protection because it increases the potential for asbestos to return to the surface); J-M chooses not to limit the number of frost penetrations but to rely instead on an inventive but unproven procedure for estimating the rate of upfreezing of waste particles.

It is the J-M procedure that, in light of the consequences of being in error, is unscientific and unreliable. Whereas the EPA procedure is validated by several decades of experience and field measurements, and does not seek to extrapolate beyond known parameters, the J-M procedure is speculative, hypothetical, and lacks substantiating data.

In further response, the reference to "shifting thermal parameters" presumably relates to the allowable number of frost penetrations into the asbestos deposit being 10 per century when the covering layers are non-frost-susceptible (sands and clean gravels) and being only 5 per century when the cover is frost-susceptible (silts and clays), as proposed by J-M. The rationale here is simply that the risk of

particles reaching the surface quickly is high with a frost-susceptible soil, requiring a balancing of that risk by further limiting the number of times the asbestos becomes frozen.

EPA cannot respond to the charges of "undocumented assumptions of questionable reliability" and "undocumented factual claims" because no information is given to identify the apparent problem areas.

It is claimed that EPA's analysis of freezing depth "omits the impact of frost heave." This claim is incorrect because the Modified Berggren equation used by EPA (as well as by J-M) makes provision for the thermal properties of the frozen soil, which include the influence of frost heave on soil density, water content, thermal conductivity, and latent heat of the freezing soil.

The Berggren equation is theoretically correct only for a step-change of temperature at the surface (i.e., a rapid change of temperature which is then held constant for the remainder of the winter); consequently a lambda coefficient was added to the equation some years ago which modifies the results produced so that they are descriptive of field experience under typical climatic temperatures. This coefficient, together with an appropriate n-value, traditionally embodies all of the correction for climate required to fit the calculated results for frost penetration to true values measured in the field for various kinds of

surface conditions.

J-M's procedure using this equation appears to calculate penetration values that are consistently less by approximately 0.5 ft. than those calculated by EPA using the same thermal parameters. J-M's consultant (C. Vita) has recently indicated that his calculated values are actually the same as the EPA values but that the estimated amount of heave has then been subtracted. Presumably, this heave value is the "impact of frost heave" referred to in the claim cited above.

To subtract the heave, however, is incorrect. EPA was informed by researchers at the U.S. Army Cold Regions Research and Engineering Laboratory, who have used this equation for several decades, that the frost penetration calculated by the equation is "the thawed value" (W. Quinn); and further, "the equation is not sufficiently precise to adjust the results for the estimated heave; the lambda coefficient takes the heave into account."

The additional claim that EPA's use of this equation is "irregular and marred by improper use of parameters" is non-specific relative to the impropriety, and as such cannot be responded to other than to state that known properties of frozen soils similar to the soils proposed by J-M were utilized in all calculations made by EPA.

Finally, it is claimed that the EPA procedure does not explicitly "account for known variability in the parameters,

and uncertainty concerning field conditions." This is partially true, although the writer has previously made this accounting using Rosenblueth's method of maximums and minimums. Based on this analysis, the writer has stated several times during the course of the several meetings held by EPA to discuss these matters that the approximate combined error in penetration depth is about  $\pm 12\%$ , or approximately  $\pm 3.0$  in. Because any known error should be on the conservative (safe) side the negative error is usually not considered. Consequently, the required 24 inches of cover should be considered an expedient value, in that the true penetration depth using the same parameters could be as high as 27 inches.

#### SPECIFIC CRITICISMS

On pages 5 to 9, the Comment makes a series of specific claims against the EPA analysis. These claims are listed separately below for reference. The EPA response follows each claim.

- a) J-M Claim: "EPA's analysis of alternative cover designs begins with a new reliability measure not previously considered in the FS or other materials. This is the potential number of times asbestos material might enter the cover in 100 years. According to the Addendum and support document, a cover should be designed to ensure that asbestos materials do not enter the covering layer more than 10 times per century (i.e., the frostline must



not enter the waste deposit (with) more than that frequency). This criterion is completely arbitrary and almost meaningless; the Addendum provides no basis for the criterion."

EPA Response: The full statement repeated above makes it clear that there was actually no confusion on J-M's part, that in fact they understood the "new" criterion as another way of stating the standard requirement of no more than 10 frostline penetrations of the waste deposit in 100 years. The essential point is that once asbestos enters the cover layer it will eventually reach the surface because of frost action; the time it takes the asbestos to move through the cover varies with the kind of soil used for the cover. It will be a very long time for a non-heaving soil such as sandy gravel, but it may be a very short time for a frost-susceptible soil such as the clayey silt being proposed by J-M for the covering soil. As noted later, a penetration frequency of 10 times per century is considered insufficiently conservative in conjunction with a full-depth highly frost-susceptible soil cover.

- b) J-M Claim: "As long as materials remain covered there could be no public health consequences from movement into the cover. It is only the frequency or likelihood that materials might come to the surface within 100 years which is or can be important."

EPA Response: J-M's claim is correct so long as materials moving into the cover either cease to move further or slow to a yearly pace that maintains them within the cover for several hundred years. Unfortunately, a frost-susceptible soil such as the clayey silt proposed by J-M causes particles to move entirely through the protective cover apparently much faster than this, which eventually eliminates the protection. The likelihood that materials will come to the surface is indeed the major problem. But the full requirement is not that they remain covered for 100 years only, as J-M asserts several times (because failure of the cover has already occurred once this has taken place). On the contrary, the requirement is one of near-permanency: i.e., at the very least, the first asbestos particle should not reach the surface for several hundreds of years, if at all.

- c) J-M Claim: "While it states that frost penetration into waste deposits 10 times per century is the appropriate goal, when it comes to analyzing the cover design in the FS, the document (McGaw's Appendix to the Addendum) shifts to a criterion of only 5 (or no) frost penetrations per century."

EPA Response: This is true, but J-M failed to notice that 10 times per century was predicated on using a non-frost-susceptible soil (sandy gravel) for the covering material. J-M's proposal to use a frost-susceptible silt for the

cover (to reduce cost) decreases the safety of the design, as noted above; consequently, a more conservative penetration interval (5 times per century) must be applied in order to offset the lowered reliability of the cover. The required increase of required cover thickness is calculated from the square root of the ratio of freezing indices for the two frequencies,  $\sqrt{1500/1300} = \sqrt{1.154} = 1.075$ . That is, an increase of 7.5% in required thickness results from the application of the more conservative criterion, namely 1.3 in. for an 18-in. total cover; 1.7 in. for a 24-in. total cover. These additional thicknesses would not be needed if J-M were proposing to use the standard covering material (sandy gravel).

- d) J-M Claim: "Only when the cover design is changed to include a sand layer does the support document shift back to relying on 10 frost penetrations per century as the objective."

EPA Response: This is true; the reason is that the non-frost-susceptible soil (sand) immediately adjacent to the asbestos provides a partial barrier to the movement of asbestos into the silty cover soil, allowing the criterion based on numbers of frost penetrations to be relaxed back to the standard value of 10.

- e) J-M Claim: "Had EPA bothered to do the analysis (or even consult Manville's updated calculations), it would have discovered that the 18-inch cover design is estimated to

permit excessive penetrations less than ten times per century, based on the thermal properties used by McGaw in his analysis."

EPA Response: This claim appears to refer to the letter of Feb. 23, 1987, from C. Vita attached to the Comment; EPA had never seen this particular analysis prior to the Comment and could not have consulted it. However, in recent verbal discussion J-M has noted that it is a letter of Dec. 19, 1986, from C. Vita that is being referred to; EPA was never furnished a copy of this letter, either. Therefore, conclusions based on unknown calculations could not be considered by EPA.

Furthermore, EPA had performed its own analysis and found that the 18-inch cover design allowed considerably more penetrations per century than ten; the reason for the discrepancy in the two calculations is apparently the result of J-M's subtracting the estimated surface heave, as previously discussed.

- f) J-M Claim: "A criterion with at least plausible substantive merit is the expected frequency of upfreezing to the surface over the long term, typically a 50- or 100-year design period."

EPA Response: Such a criterion would indeed be plausible if the "long-term" design period assumed by J-M were not too short. EPA has never quoted a 50-year period, and

even the 100-year period is misunderstood by J-M in this Comment; 100 years was selected by EPA as the basis for the frequency of frost penetrations, not the allowable period for asbestos to move through the cover! This latter period must be considerably longer than 100 years if the Legislative mandate of "permanent" protection is to be adhered to.

- g) J-M Claim: "The thermal properties used by McGaw in the Addendum and those in the FS are different."

EPA Response: This is true. However, EPA's thermal parameters of Dec. 5, 1986, were furnished to J-M prior to their submittal of the revised FS. J-M did not incorporate them into the FS even though J-M had apparently received new calculations from C. Vita dated Dec. 18, 1986, which utilized these parameters.

- h) J-M Claim: "Using updated parameters, the 18-inch proposal can be seen to be extraordinarily protective. Asbestos materials would not be expected to reach the surface for almost 700 years... The absolute lower bound estimate of breakthrough time for EPA's 24-inch proposal (with a six-inch sand layer) is 239 years, while that of the 18-inch proposal (with six inches of sand) is 222 years."

EPA Response: The years for upfreezing of asbestos referred to in the above claim are different from those

presented in the FS (greater by approximately 150 years), and apparently result from calculations which were not available to EPA at the time the Addendum to the FS was prepared. EPA has recently received these calculations from C. Vita and finds them to be based on assumptions of upfreezing rate that have not been validated by experiment or field experience. (Further response follows the next claim below.

- i) J-M Claim: "Both designs (the 24-inch and the 18-inch) are predicted to assure virtually total reliability for a 100- and even a 200-year design horizon. Spending more money for a 24-inch cover cannot be justified on any principled basis using EPA's analysis. Accordingly, EPA should withdraw its flawed analysis and its 24-inch proposal."

EPA Response: J-M is in error when it claims total reliability based only upon calculations resulting from a theory of upfreezing rate which has not been proven. The theoretical model devised by C. Vita is no more than a first approximation of the physical processes that actually take place when a particle of asbestos is imbedded in a freezing soil. The model and its results have not been published in the open literature and evaluated by others against the state-of-the-art. Until this has occurred, and validating experiments or field measurements made, data resulting from use of the model

must be accepted as guideline only; a calculated degree of "reliability" is not the same as assurance that field results will be the same as those predicted by the model.

NOTE: EPA is charged with protection of the public health from the medical hazards of waste asbestos. EPA's analysis, and the requirement of 24 inches of soil cover based on this analysis, admittedly do not represent complete assurance that no future medical hazard will develop because of frost action. When so many unknowns are present because of assumptions made relative to climate, properties of soils, and mechanisms of frost heaving and particle migration, there is no way to assure complete and permanent protection. On the other hand, EPA's analysis relies on fewer assumptions and is a conservative application of an accepted and validated procedure for calculating frost penetration through soils. It is also an expedient approach which accepts a degree of risk balanced against the total cost, as is required by the governing regulations. J-M's own analysis shows that the EPA 24-inch cover thickness provides longer-term protection but costs only 10% more than the 18-inch cover proposed by J-M. For these reasons EPA cannot withdraw the 24-inch requirement.

j) J-M Claim: "EPA exaggerates potential impacts of the site by implying the waste-asbestos containing material that is currently encapsulated will soon break down and become friable due to the action of ground water, rain, sunlight, air, and wind. EPA provides no basis for this assertion

nor any scientific explanation of how it will occur... The asbestos-containing products manufactured at the site were explicitly designed to be used outdoors and to withstand exposures to weather... Chunks or particles reaching the surface will not become friable in any meaningful time frame."

EPA Response: J-M's assertions here are incorrect. The primary bonding agents used at the site are silicates and gypsum (cement) and asphalt. It is well-known that sunlight and moisture, and particularly freezing moisture, deteriorate these materials. The silicate agents are also highly alkaline and susceptible to chemical attack by acid rain and ground water. The products manufactured at the site were of course designed to be weather-resistant; nevertheless, they are not weather-proof, and deterioration to a friable condition may indeed eventually occur. As for a "meaningful" time frame, the writer has observed cement-bonded asbestos board lying on the surface at other sites in such a rotted condition that any disturbance would cause the apparent structure to vanish; yet these scraps had been exposed on the surface for no more than 2 to 5 years. It is also quite possible that a significant degree of this structural breakdown had occurred during the upfreezing period, even before exposure to air and sunlight.



## CONCLUSION

In the Introduction to the Comments discussed above, J-M states that they strongly disagree with the conclusion of EPA's Addendum to the Final Feasibility Study, i.e., to continue to recommend a 24-inch cover over the asbestos material at the Waukegan plant site. The reasons given are that EPA's decision rule for cover thickness is without basis, and its supporting analysis is both flawed and inconsistent.

J-M clearly believes that an 18-inch cover appropriately maintained is fully adequate to address conditions at the site, and that EPA's 24-inch requirement should be withdrawn. They base this belief on the results of a computer model of upfreezing rate which appears to demonstrate that even with an 18-inch cover thickness of frost-susceptible soil, asbestos could not reach the surface for almost 700 years.

The approach J-M's consultant (C. Vita) has developed for estimating the time it will take for asbestos to reach the surface is a good one, and if validation demonstrates that it produces correct results for various types of soils and climates, it may become part of the basis for future asbestos cover designs. Unfortunately for the present project, it represents an unproven procedure that shows some deviation from the standard EPA requirements, but this deviation cannot be relied on at the present stage of development. The reason is that we are dealing with an issue of public health, which requires a conservative solution.

Because the J-M procedure has no precedent, it is possible that the computer results could have shown that a 30-inch or greater cover was needed for maintaining the asbestos below the surface for the first 100 years. In that case, it is probable that the EPA results would have been acceptable to J-M because the cost would have been less.

And that is the ultimate argument; because the EPA procedure, however overdesigned it may be (if at all), is a state-of-the-art process it gives a greater final assurance against failure of the cover. It is believed that the responses given above to J-M's claims demonstrate that fact. For this basic reason the 24-inch cover thickness for the Waukegan site must be held to by EPA.

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